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A CENSUS OF THE TREE SPECIES IN THE GOLAPBAG CAMPUS OF BURDWAN UNIVERSITY, WEST BENGAL (INDIA) WITH THEIR IUCN RED LIST STATUS AND CARBON SEQUESTRATION POTENTIAL OF SOME SELECTED SPECIES

SHARMISTHA GANGULY[a1] AND AMBARISH MUKHERJEE[b]

[a]UGC CAS Department of Botany, University of Burdwan, Burdwan, West Bengal, India

ABSTRACT

The present census brings out an inventory of tree species in the Golapbag campus of The University of Burdwan, Burdwan in the West Bengal State of India. As many as 91 species belonging to 82 genera of 39 families, of which of which 85 species of 76 genera representing 38 families are dicotyledonous and 6 species of one family(Arecaceae) are monocotyledonous, could be included in the checklist thus prepared. Many of these species are botanically interesting, attractive and potentially sources of various phytoresources and aesthetic pleasure. The IUCN Red List status of each of these species was determined. Six of the dominating species were worked to reveal their carbon sequestration potential with an objective to find their utilitarian value in landscape designing for aesthetic rejuvenation and environmental optimization. It was found that Ficus benghalensis is the best of the lot in Carbon sequestration being successively followed by *Mimusops elengi*, *Roystonia regia*, *Senna siamea*, *Dalbergia lanceolaria* and *Cassia fistula*. Thus, it can be concluded that the trees composing the campus flora needs to be protected and some of them can well be chosen for further evaluation of their environment credentials in green-belt development especially polluted urban localities.

KEYWORDS : Tree Species, Carbon Sequestration, Environmental Optimization, Landscape Designing

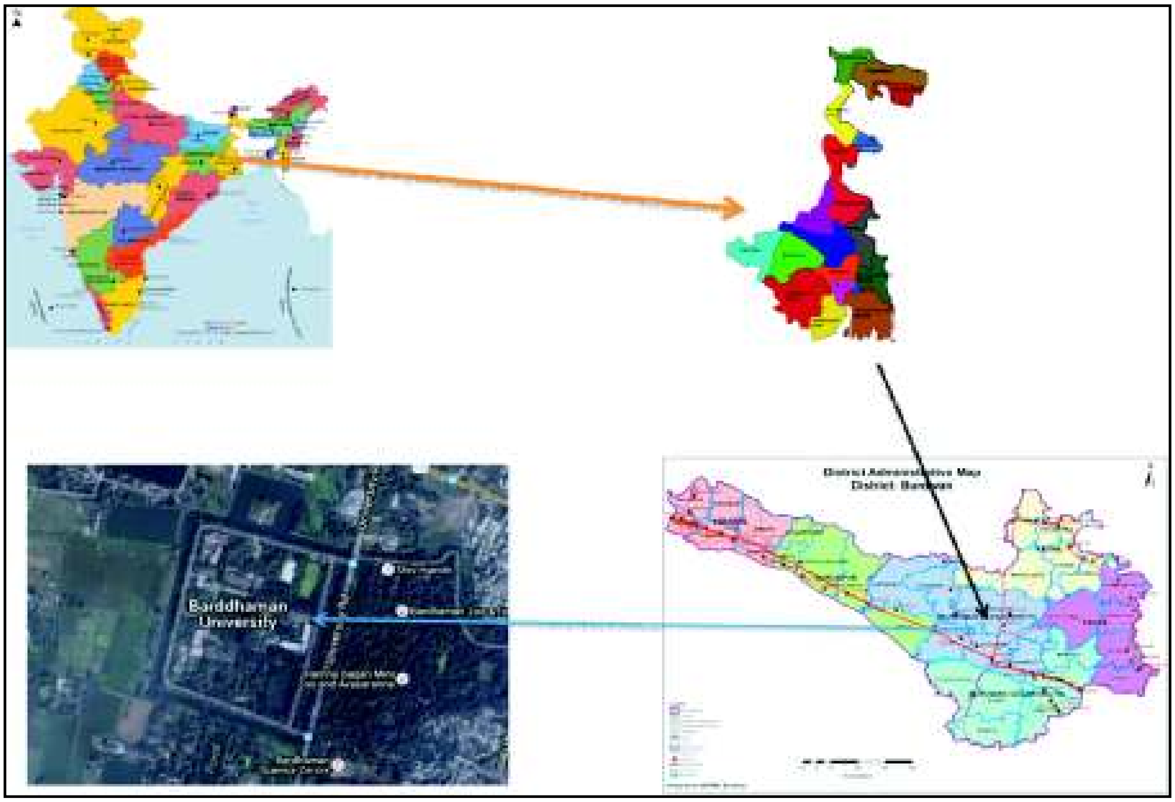
Presently global warming is one of the most important environmental issues which together with destruction of nature, a usual event in development, have been worsening the situation so that scientists have to work out methods of resilience to optimize environment through green-belt development and landscape designing that collaterally boost up aesthetic rejuvenation of the area. Carbon sequestration potential of a plant, one of the parameters essential for its selection in green belt development, is defined as absorption of carbon dioxide by the plants from the surrounding atmosphere (Pandya et al., 2013) and its storage in the form of biomass in the tree trunks, branches, foliages and roots that can be re-emitted in the form of gaseous carbon dioxide if the biomass is incinerated (Das and Mukherjee, 2015).

Terrestrial ecosystem represents the most important sources and sinks of atmospheric carbon (Watson and Core, 2001) with 24% of net annual anthropogenic GHGs of the atmosphere (Prentice et al., 2001). Carbon sequestration potential depends of several factors such as types of species, types of soil, regional climate, topography and management practices. Global carbon cycle is maintained by CO_2 exchange with the atmosphere where forest ecosystem plays a vital role (Vashum and Jaykumar, 2012) because trees are the reservoir of carbon on the earth due to their potentiality of photosynthesis. Since tree- and shrub- species richness are more relied upon in optimization programmes, the present authors took up the census work on trees of the Golapbag campus of the University of Burdwan and revelation of the carbon sequestration potential of six of the dominating species in them. The campus selected as the study site shows a unique assemblage of many indigenous species with the exotic ones in form of ornamentals, weeds, vines, epiphytes and trees.

Study Site

Golapbag, the once royal garden of the Maharaja of Barddhaman (Burdwan), is the academic campus of Burdwan University located at 23.25° N 87.85°E with an average elevation of 40 meters (131 ft) above the mean sea level. It is a little less than 100 km north-west of Kolkata. Golapbag or garden of roses is a beautiful place which was the botanical and zoological garden established by the king Bijoy Chand Mahatab in 1884 with technical advice from the then British experts in the subject. The famous botanist Sir J. D Hooker had paid a visit to the area and enlisted 128 types of trees. At present there are numerous individual trees of *Polyalthia longifolia, Swietenia mahagoni, Drypetes roxburghii, Saraca asoca, Albizia saman, Dolichandrone stipulata, Manilkara hexandra, Aphanamyxis polystachia, Naringi crenulata,Pongamia pinnata, Barringtonia acutangula*, and several others in the garden. A large

[1]**Corresponding author**



Study Map

number of species are unique to the campus for having been either introduced or surviving as the reminiscent of the indigenous flora that no more exists outside. Among the introduced ones Brownea coccinea, Jacquinea ruscifolia, Amherstia nobilis deserve mention. A number of factors such as variation in microhabitats, plenty of land open to plant invasion, willful introduction of species for avenue plantation, ornamentation and botanical studies, high anthropogenic concern etc. have led to the assemblage of plants of admirable distinction.

The plant diversity of the campus has been proving its worth in conveying ecological and sociocultural benevolence to the society in several ways. The greenery of the campus together with Ramnabagan Wildlife Sanctuary has been optimizing the environment by constituting a green patch in the peri-urban area of Bardhaman city to sustain a wide diversity of fauna and abate pollution . However the campus has been experiencing threats of biodiversity impoverishment especially of the rare species.

METHODOLOGY

Trees growing the campus of the University were studied by the present authors. Specimens from them were worked out following standard taxonomic methods for identification. For confirmation of identification pertinent literature was consulted (Prain, 1903; Bennet, 1987;Guha Bashi, 1984) and for updating of nomenclature The websites of International Plant Names Index (IPNI), The Plant List and Tropicos were also consulted. The IUCN Red List Status of each species was also checked. Among the dominating species of the study site as many as six species were selected and the girth of each was measured conventionally at the breast height (GBH) i.e. near about 1.32m above ground surface. Tree diameter (D) was calculated by dividing π (22/7) by the actual marked girth of species (Bohre et al., 2012) i.e. GBH x (7/22). Biomass of the listed phanerophytes was calculated by simply applying bio-statistics based on allometric equations. Above ground Biomass i.e. AGB were measured by multiplying the bio-volume to the green wood density of tree species. Tree bio-

Table 1 : Census of The Arborescent Trees of Golapbag Campus

Serial No.	Scientific Name	Family	Common Name	IUCN Red List Status	Total no.
1.	*Acacia auriculiformis* Benth.	Fabaceae	Ear leaf acacia	Least Concern Version 3.1, Pop trend : Stable	8
2.	*Acacia nilotica*(L.) Willd. ex.Delile	Fabaceae	Babool	Not yet assessed	2
3.	*Acacia pinnata* Link. (Unresolved)	Fabaceae	climbing wattle	Not Assessed	10
4.	*Aegle marmelos* (L.) Corrêa	Rutaceae	Bel	Not Assessed	9
5.	*Aganosma acuminata* G.Don	Apocynaceae	Malati lata-	Not yet assessed	1
6.	*Ailanthus excelsa* Roxb.	Simaroubaceae	Tree of Heaven, Mahanimb	Not Assessed	1
7.	*Alangium lamarckii* Thwaites	Alangiaceae	Ankol	Not yet assessed	1
8.	*Albizia lebbeck* (L.) Willd.	Fabaceae	Siris-	Not Assessed	1
9.	*Albizia saman* (Jacq.) Merr.	Mimosaceae	Rain Tree	Not Assessed	14
10.	*Aleurities mollucana* (L.) Willd.	Euphorbiaceae	Candleberry, Indian walnut, Kemiri,	Not Assessed	1
11.	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Chattim	Lower Risk/Least Concern, Version 2.3	1
12.	*Amherstia nobilis* Wall.	Fabaceae	Urbasi	Critically Endangered	1
13.	*Anthocephalus indicus* A.Rich.	Rubiaceae	Kadam	Not yet assessed	1
14.	*Aphanamixis polystachya* (Wall.) R. Parker	Meliaceae	Pithraj Tree	Not Assessed	7
15.	*Areca catechu* L.	Arecaceae	Supari	Not yet assessed	3
16.	*Artocarpus heterophyllus* Lam.	Moraceae	Jackfruit	Not Assessed	4
17.	*Artocarpus lacucha* Buch.-Ham.	Moraceae	Lakoocha	Not Assessed	2
18.	*Averrhoa carambola* L.	Oxalidaceae	Karmal	Not yet assessed	2
19.	*Azardirachta indica* A. Juss.	Meliaceae	Neem	Not yet assessed	1
20.	*Barringtonia acutangula* (L.) Gaertn.	Lecythidaceae	Hijal	Not Assessed	3
21.	*Bauhinia purpurea* L.	Caesalpinaceae	Koiral	Not yet assessed	1
22.	*Borasus flabellifer* L.	Arecaceae	Toddy palm	Endangered B2ab(iii); D Version 3.1 Pop trend : Unknown	5
23.	*Bridelia retusa*(L.) A. Juss.	Phyllanthaceae	Geio	Not yet assessed	5
24.	*Brownea coccinea* Jacq.	Fabaceae	Supti	Not Assessed	4
25.	*Butea monosperma (*Lam.) Taub.	Fabaceae	Palash	Not Assessed	1
26.	*Cassia fistula* L.	Fabaceae	Amaltas	Not Assessed	11
27.	*Casuarina equisetifolia* L.	Casuarinaceae	Belati-Jhau	Not Assessed	2
28.	*Citrus maxima* (Burm.) Merr.	Rutaceae	Chakotra	Not Assessed	1
29.	*Congea tomentosa* Roxb.	Asteraceae	Chinese thuja	Not yet assessed	2
30.	*Cordia myxa* L.	Boraginaceae	Bonary	Not Assessed	3
31.	*Corypha utan* Lam.	Arecaceae	Buri palm	Not Assessed	1
32.	*Couroupita guianensis* Aubl.	Lecythidaceae	Nagalinga	Lower Risk/ Least Concern Version 2.3	1
33.	*Dalbergia lanceolaria* L. f.	Fabaceae	Takoli	Least Concern Version 3.1	11

34.	*Diospyros evena* Bakh.	Ebenaceae	-	Not yet assessed	2
35.	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae	Malabarebony ; Gaub, Desi Gab	Not Assessed	1
36.	*Discladium squarrosum* (L.) Tiegh.	Ochnaceae	-	Not Assessed	2
37.	*Drypetes roxburghii*(Wall.)Hurus.	Euphorbiaceae	Jioysuta	Not yet assessed	22
38.	*Ficus benghalensis* L.	Moraceae	Bot	Not Assessed	16
39.	*Ficus racemosa* L.	Moraceae	Goolar	Not Assessed	2
40.	*Ficus religiosa* L.	Moraceae	Peepal	Not Assessed	2
41.	*Gelonium multiflorum* A. Juss.	Euphorbiaceae	Ban Naranga	Not yet assessed	1
42.	*Glochidium hirsutum*	Euphorbiaceae	-	Not yet assessed	2
43.	*Grewia asiatica* L.	Malvaceae	Falsa	Not Assessed	5
44.	*Holarrhena pubescens* Wall. ex G. Don.	Apocynaceae	Indrajao	Least Concern Version 3.1	3
45.	*Holoptelea integrifolia Planch.* (Unresolved)	Ulmaceae	Nata karanja	Not Assessed	4
46.	*Kleinhovia hospita* L.	Sterculiaceae	Bola	Not yet assessed	1
47.	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	Jarul	Not Assessed	53
48.	*Litchi chinensis* Sonn.	Sapindaceae	Lichi	Not yet assessed	2
49.	*Litsea glutinosa*(Lour) C.B.Rob.	Lauraceae	Bolly beech	Not yet assessed	3
50.	*Livistona chinensis* (Jacq.) R.Br.ex.Mart.	Arecaceae	Fountain palm	Not yet assessed	1
51.	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	champa	Not yet assessed	1
52.	*Mallotus roxburghianus* Müll.Arg.	Euphorbiaceae		Not Assessed	4
53.	*Mangifera indica* L.	Anacardiaceae	Aam	Not Assessed	20
54.	*Manilkara hexandra* (Roxb.) Dubard.	Sapotaceae	Khirni	Not Assessed	5
55.	*Markhamia stipulata* (Wall.) Seem.	Bignoniaceae	-	Not Assessed	31
56.	*Melia azadirachta* L.	Meliaceae	Neem	Not yet assessed	1
57.	*Mesua ferrea* L.	Calophyllaceae	Nag kesar	Not Assessed	1
58.	*Mimusops elengi* L.	Sapotaceae	Bakul	Not Assessed	21
59.	*Mitragyna parvifolia* (Roxb.) Korth.	Rubiaceae	Kadamb	Not Assessed	1
60.	*Morinda citrifolia* L.	Rubiaceae	Hurdi	Not Assessed	4
61.	*Murraya paniculata* (L.) Jack.	Rutaceae	Kunti	Not yet assessed	2
62.	*Murraya paniculata* (L.) Jack.	Rutaceae	Kamini	Not Assessed	2
63.	*Naringi crenulata*(Roxb.)D.H.Nicolson	Rutaceae	Naringi mul	Not yet assessed	1
64.	*Nyctanthes arbor-tristis* L.	Oleaceae	Har singar	Not Assessed	1
65.	*Pavetta indica* L.	Rubiaceae	Jui	Not yet assessed	1
66.	*Peltophorum ferrugineum* (Decne.) Benth.	Fabaceae	Peela gulmohar	Not Assessed	1
67.	*Peltophorum pterocarpum* (DC.) K.Heyne	Fabaceae	Peela gulmohar	Not yet assessed	1
68.	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Kharjura	Not Assessed	1
69.	*Plumeria obtusa* L.	Apocynaceae	Kathgolop	Not Assessed	2
70.	*Polyalthia longifolia* (Sonn.) Thwaites	Annonaceae	Ashok	Not Assessed	375
71.	*Pongamia glabra* L.	Fabaceae	Karanj	Not yet assessed	7

72.	*Pterospermum acerifolium* (L.) Willd.	Malvaceae	Muskanda	Not Assessed	5
73.	*Pterygota alata* (Roxb.) R.Br.	Sterculiaceae	Tula	Not yet assessed	2
74.	*Putranjiva roxburghii* Wall.	Putranjivaceae	Pitranjiva	Not Assessed	34
75.	*Roystonia regia* (Kunth.) O. F. Cook	Arecaceae	Royal palm	Not Assessed	14
76.	*Saraca asoca* (Roxb.) Willd.	Fabaceae	Sita ashok	Vulnerable B1 + 2c , Version 2.3	64
77.	*Schleichera oleosa* (Lour)Oken	Sapindaceae	Kusum	Not yet assessed	1
78.	*Senna siamea* (Lam.) H. S. Irwin & Barneby	Fabaceae	Kassod	Not Assessed	21
79.	*Spondias dulcis* Parkinson.	Anacardiaceae	Hog plums	Not Assessed	1
80.	*Sterculia urens* Roxb.	Malvaceae	Kulu	Not yet assessed	5
81.	*Streblus asper* Lour.	Moraceae	Shewra	Not Assessed	7
82.	*Swietenia macrophylla* King.	Meliaceae	Honduran mahogani	Vulnerable A1cd + 2cd; Version 2.3	3
83.	*Swietenia mahogani* L.	Meliaceae	Mahogani	Not Assessed	80
84.	*Symplocos racemosa* Roxb.	Symplococeae	Lodhra	Not yet assessed	1
85.	*Syzygium aqueum* (Burm. f.) Alston.	Myrtaceae	Golapjaam	Not Assessed	3
86.	*Tabebuia aurea (Silva Manso)* Benth. et Hook.f. ex S. Moore	Bignoniaceae	Tree of Gold-	Not yet assessed	1
87.	*Tamarindus indica* L.	Fabaceae	Telul	Not yet assessed	2
88.	*Tectona grandis* L. f.	Lamiaceae	Saguna	Not Assessed	4
89.	*Thunbergia coccinea* Wall.	Acanthaceae	Neel lota	Not yet assessed	1
90.	*Trem a orientalis* (L.) Blume.	Cannabaceae	Chikan	Not yet Assessed	5
91.	*Wrightia tomentosa* (Roxb)Roem.& Schult	Apocynaceae	-	Not yet assessed	1

volume (TBV) value was established by multiplication of square of diameter with height of phanerophytes to factor 0.4.

$$\text{Bio-volume } (T_{BV}) = 0.4 \text{ X } D^2 \text{ x } H$$

$$\text{AGB=Wood density x } T_{BV}$$

Where: D is calculated from GBH, assuming the trunk to be cylindrical, H = Height in meter. Height is measured with the help of the instrument Theodolite. Wood density is used from Global wood density database (Zanne et al., 2009). The standard average density of 0.6 gm/ cm3 was applied wherever the density value was not available for tree species. The below ground biomass was calculated by multiplying the above ground biomass (AGB) by 0.26 factors as the root: shoot ratio (Hangarge et al., 2012).

$$\text{BGB =AGB x 0.26}$$

Total biomass is the sum of the above and below ground biomass (Sheikh et al, 2011).

Total Biomass (TB) = Above Ground Biomass + Below Ground Biomass.

Carbon Estimation Generally, for any plant species 50% of its biomass is considered as carbon (Pearson et al., 2005) i.e.Carbon Storage/ Carbon sequestration potential = Biomass /2

RESULTS AND DISCUSSION

In the inventory of tree species in the Golapbag campus (Table 1) includes as many as 91 species belonging to 82 genera of 39 families could be included. Of the total species no less than 85 species of 76 genera representing 38 families are dicotyledonous and 6 species of one family (Arecaceae) are monocotyledonous. Taxonomic analysis of the trees reveals dominance of Dicots over Monocots at the levels of species, genus and families, the values being 14:1; 12.66:1 and 38:1 respectively (Table 2 and Figure1).

Many of these species are botanically interesting, attractive and potentially sources of various phytoresources and aesthetic pleasure. However the IUCN Red List Status of 82 Campus trees is yet to be determined and 3 are least

Table 2 : Taxonomic Analysis of The Trees in Golapbag Campus

Taxa	Dicots	Monocots	Ratio Dicots: Monocots
Species	84	6	14:1
Genus	76	6	12.66:1
Family	38	1	38:1

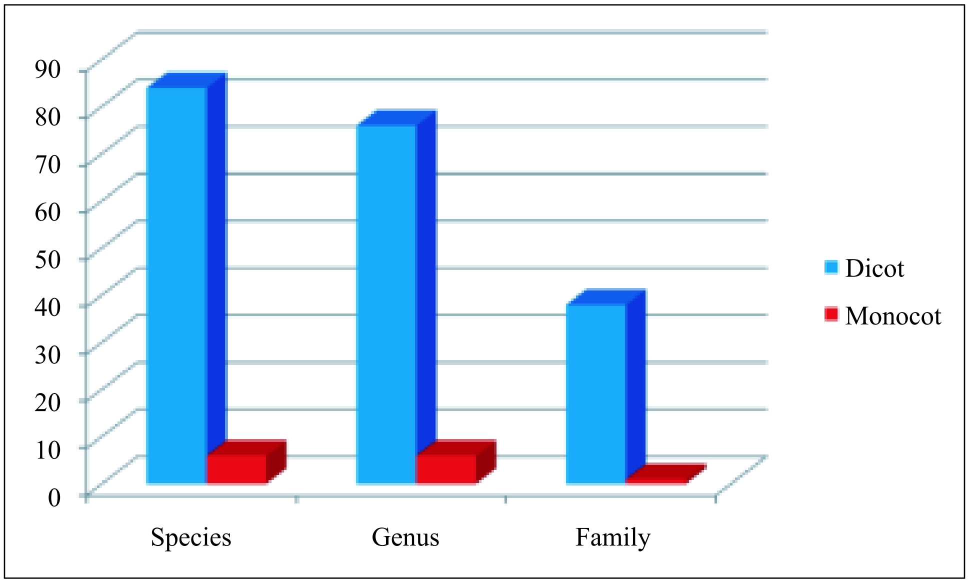


Figure 1: Taxonomic Analysis Showing Dicot-monocot Ratio

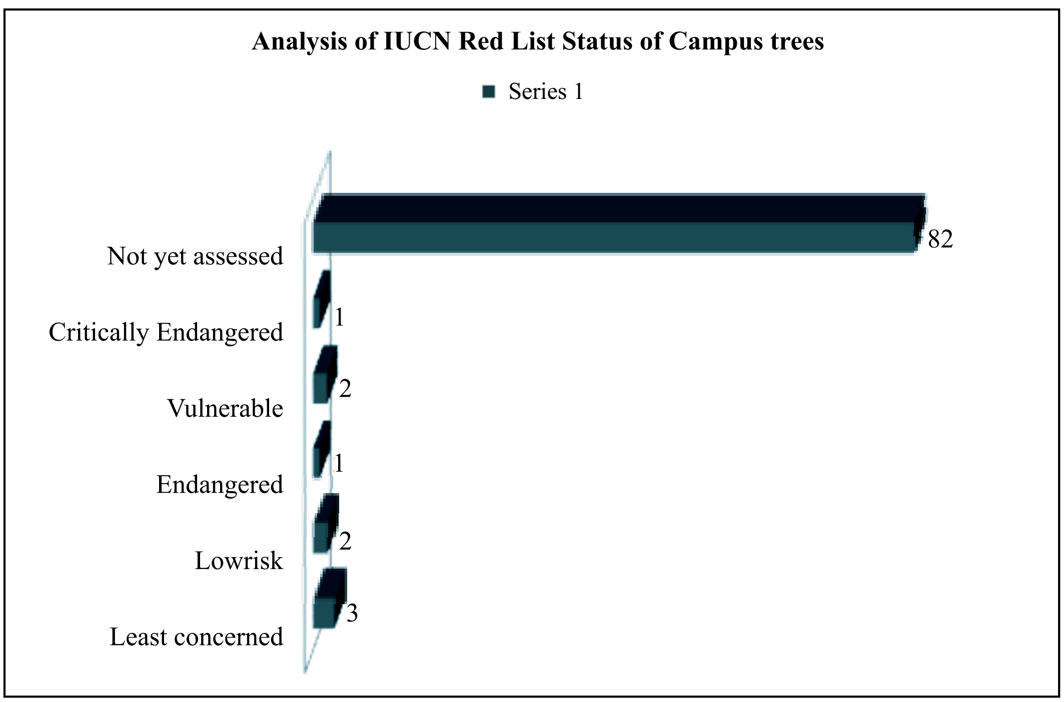


Figure 2 : Analysis of IUCN Red List Status of Campus Trees.

Table 2 : Carbon Sequestration Potential of Six Dominating Species of Golapbag Campus

Name of plant	Plant No.	GBH (in meter)	Diameter (in meter)	Height (in meter)	T_{BV} (m^3)	AGB in Kg	BGB (Kg)	TB (Kg)	Carbon Storage (Gram)	Mean value of Carbon Storage (Gram)
Cassia fistula L.	1	0.80	0.2545	9.1	0.2358	0.1414	0.0367	0.1781	89.05	89.92
	2	1.05	0.3340	10.1	0.4509	0.2705	0.0703	0.3408	170.4	
	3	0.72	0.2290	10.3	0.2162	0.1297	0.0337	0.1634	81.70	
	4	0.30	0.0954	10.1	0.0368	0.0220	0.0057	0.0277	13.85	
	5	0.75	0.2386	9.25	0.2107	0.1264	0.0328	0.1592	79.60	
Dalbergia lanceolaria L. f.	1	1.03	0.3277	9	0.3866	0.2319	0.0603	0.2922	146.1	227.7
	2	0.73	0.2322	8.25	0.1780	0.1068	0.0277	0.1345	67.25	
	3	2.10	0.6681	10.3	1.8394	1.1036	0.2869	1.3905	695.25	
	4	0.46	0.1463	4.2	0.0359	0.0215	0.0056	0.0271	13.55	
	5	1.16	0.3690	10.4	0.5667	0.3400	0.0884	0.4284	214.2	
Ficus benghalensis L.	1	3.77	1.1995	10.3	5.9283	3.5569	0.9248	4.4817	2240.85	3847.02
	2	2.55	0.8113	8	2.1065	1.2639	0.3286	1.5925	796.25	
	3	4.02	1.2790	9.1	5.9553	3.5731	0.9290	4.5021	2251.05	
	4	3.35	1.0659	12	5.4535	3.2721	0.8507	4.1228	2061.40	
	5	6.86	2.1827	16.5	31.444	18.866	4.9051	23.771	11885.55	
Mimusops elengi L.	1	1.95	0.6204	9.25	1.4243	0.8545	0.2221	1.0766	538.30	903.5
	2	1.00	0.3181	7	0.2834	0.1700	0.0442	0.2142	107.10	
	3	2.45	0.7795	9.3	2.2606	1.3596	0.3534	1.7130	856.50	
	4	3.80	1.2090	9.2	5.3797	3.2278	0.8392	4.0670	2033.5	
	5	2.67	0.8495	9	2.5982	1.5589	0.4053	1.9642	982.10	
Roystonia regia (Kunth.) O. F. Cook	1	1.80	0.5727	16	2.0993	1.2595	0.3274	1.5869	793.45	554.41
	2	1.33	0.4231	15	1.0744	0.6446	0.1676	0.8122	406.10	
	3	1.35	0.4295	15.1	1.1144	0.6686	0.1738	0.8424	421.20	
	4	1.52	0.4836	15.7	1.4689	0.8813	0.2291	1.1104	555.20	
	5	1.57	0.4995	15.8	1.5771	0.9462	0.2460	1.1922	596.10	
Senna siamea (Lam.) H. S. Irwin & Barneby	1	1.80	0.5727	8.25	1.0824	0.6494	0.1688	0.8182	409.10	449.12
	2	1.90	0.6045	9.1	1.3303	0.7981	0.2075	1.0056	502.80	
	3	1.22	0.3881	9.25	0.5575	0.3345	0.0869	0.4214	210.70	
	4	2.00	0.6363	10	1.6198	0.9718	0.2526	1.2244	612.20	
	5	1.80	0.5727	10.3	1.3514	0.8108	0.2108	1.0216	510.80	

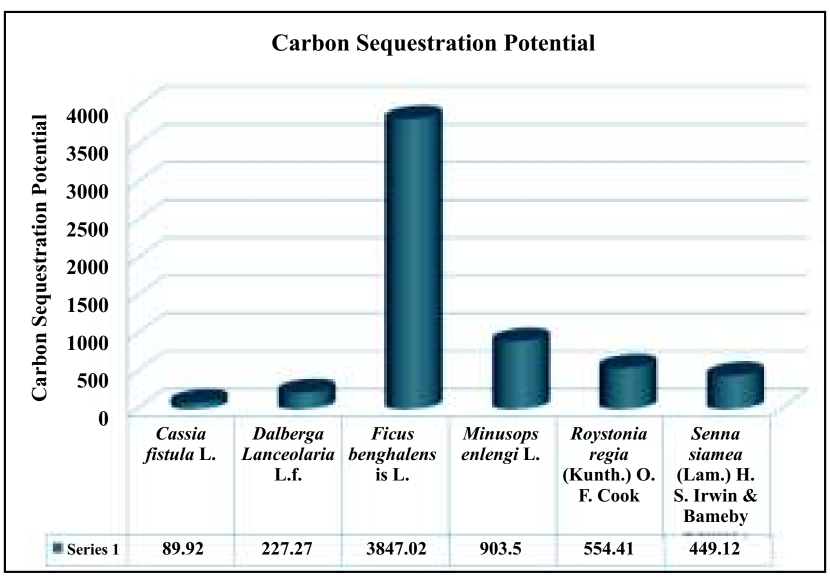


Figure 3: Carbon Sequestration Potential of Six Dominating Species of Golapbag Campus.

concerned (Table 1 and Figure 2). Threat perceptions of remaining six species being alarming their protection and conservation are deemed essential.

The carbon sequestration potential of 5 individual trees belonging to each of six different genera was determined of which *Ficus benghalensis* has registered the highest (3847.02 gm) and *Cassia fistula* the lowest values(89.92 gm). Carbon sequestration values of other species were 227.27, 903.5, 554.41, 449.12 grams incase of *Dalbergia sisso, Mimusops elengi, Roystonia regia* and *Senna siamea* respectively. So, it can be concluded that each of the tree species has considerable contribution in subduing the level of CO_2 in the campus and cooling the ambience.

CONCLUSION

Golapbag campus of Burdwan University is a biodiversity rich area with a lot of phytoresources including medicinal plants (Hotwani and Mukherjee, 2005a and 2005b). Moreover there are quite a significant number of arborescent species (Namhata and Mukherjee, 1990). It is also seen from publications on trees of Golapbag campus that carbon sequestration potential varies from species to species (Das and Mukherjee, 2015). These authors found that Swietenia mahagoni successively followed by Albezia saman, Polyalthia longifolia, Drypetes roxburghii, Mangifera indica, Saraca asoca, Dolichandrone stipulata and Lagestroemia speciosa are with high efficiency to sequester atmospheric CO2 and the present author registers Ficus benghalensis as the best in this regard. The entire association of plants in the campus contributes enormously to the greenery of the campus thus generating aesthetic pleasure. Many of them have proved them to be useful in monitoring and scavenging air pollution (Ghosh and Mukherjee, 2003) in and around Golapbag Campus. Some of the species, especially Amherstia nobilis, have been perceiving threats of extinction mainly from anthropogenic activities in the campus they deserve attention for their protection and sustenance along with other species.

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